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PROBLEMS OF SUMMER ROOM HEATING

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16. Abstract

Modern buildings have large window glass surfaces and in summertime, depending on glass type and wall material, room temperatures can become intolerable. To solve this problem, architects should choose suitable building materials for inner rooms rather than use expensive air-conditioning systems.

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PROBLEMS OF SUMMER ROOM HEATING

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Under the slogan "light as construction material", the last decades have seen a development in the direction of ever greater window surfaces - to the complete resolution of external walls into glass. This method of construction expresses a "construction attitude" which envisions inclusion of the outside world into the limited inner space. /60

The larger glass surfaces entail a corresponding higher influx of heat into the room. In the train of this development, therefore, there soon came complaints about the high summer temperature of the rooms. This brought about a new rethinking of the problem of summer room heating, and the technical radiation behavior of glasses was subjected to critical examination.

The technical radiation difference between glasses and other construction material consists in the fact that the incident radiation is not only absorbed and reflected, but - because of their transparency - is to a considerable extent transmitted. The fraction of admitted, absorbed, and reflected radiation depends on the type of glass and on the angle of incidence of sun radiation. Only the transmitted and absorbed portions of radiation generally contribute to room heating. The absorbed portion contributes because it leads to a warming of the glass and consequently to an additional (secondary) heat transfer via the glass pane into the room through convection and long-wave radiation.

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*Numbers in righthand margin indicate pagination of foreign text.

Extensive investigations have been made at the experimental station at Holzkirchen concerning these technical radiation processes and the room heating resulting therefrom. To characterize the energy delivery of glasses, a new characteristic quantity, the so-called "glass characteristic G" was introduced and used successfully in calculations concerning room heating. The glass characteristic G represents the percentage of sun energy which reaches the room through a given glassy material during one radiation day - considering the continuous changes of angle of incident of sun radiation. According to this definition, the G value moves /61 within the limits of G 0 for an imaginary, completely energy-impenetrable window and G 100 for an "ideal" radiation transparent pane. A "normal" double glass has a characteristic G value of 60. Sun protective glasses lie in the characteristic domain of G 25 to G 50. Glasses with effective sun protection may have characteristic G values smaller than 25. Simple panes of clear glass have characteristic values greater than G 60.

A proper insight into the relationships during summer room heating is gathered from considerations of heat balance. Such considerations derive from the operative effect of heat brought in by solar energy, as characterized by the G value, and heat taken up by the room dividing partitions or heat removal through climatological-technical devices. Theoretical and practical evaluation of such balancing considerations meets with particular difficulty in the present case because solar radiation is not constant in time, but - corresponding to the orientation of the window as well as to the time of day and of year - follows a definite, naturally prescribed, fluctuating time function. Correspondingly, the calculation of heat absorption by the room enclosures must include a relatively complicated non-stationary heat flow equation. In addition to the conductivity of the materials, the specific heat capacity is also a parameter in these equations.

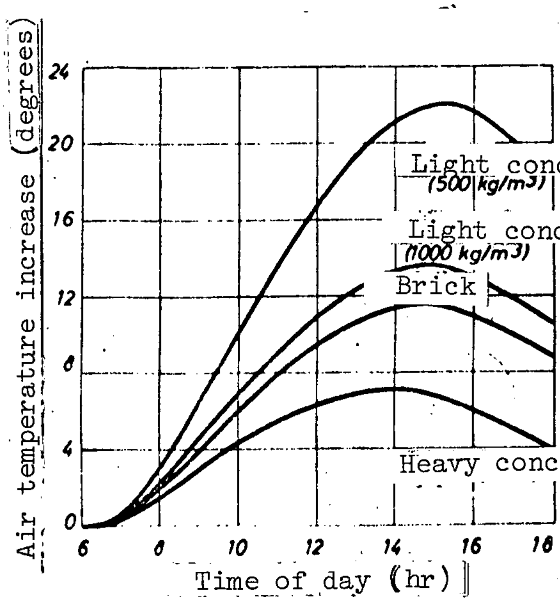

Fig. 1. Temporary loss of the air temperature of a room inside a building complex having 15 cm thick inner construction parts of different materials, with some radiation during the day and equal periods of night and day.

Room size: 4 m x 4 m x 2.5 m (normal room)

Glass construction:
glass surface: 4 m^2
(southern orientation)
type of glass : clear glass, double panes

Weight of construction materials:
light concrete: 500 kg/m^3
1000 kg/m^3
brick: 1500 kg/m^3
heavy concrete: 2500 kg/m^3

The effect of the heat capacity of the enclosing building materials upon the summer room heating has not been adequately considered heretofore. As calculation of various cases showed, the heat capacity of the construction materials of which the inner limits of room are built, is of considerable importance. In its effect on room heating the importance of heat capacity equals that of window size. Fig. 1 shows this clearly. Here the time developments of the air temperature during a summer day with plenty of radiation are compared with one another, if - for similar room size and window construction - the room enclosures are made of different materials. Rooms of light construction (for example, light concrete) warm up relatively greatly because of the small heat capacity of the light materials, while rooms made of heavy building /62 material with greater heat capacity remain considerably cooler. For example, the maximum temperature in the heavy concrete room was only about a third of the maximum temperature which is found in a room made with light concrete with a weight of 500 kg/cm^3.

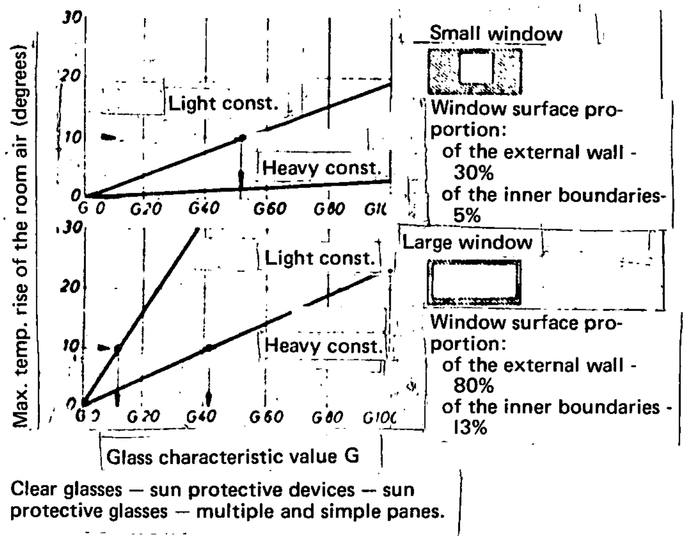

Fig. 2. Maximum rise in air temperature in a room of light and heavy construction with different large southern windows, which is equipt with glass in different ways.

Room size: 4m x 4m x 2.5m

Light construction: 20 cm light concrete (500 kg/cm^3)

Heavy construction: 20 cm heavy concrete (2500 kg/cm^3)

(Sun radiation during day and equal periods for day and night.)

Despite this indesputable advantage of heavy inner construction from the point of view of thermal consideration, light partitions are preferred in office and school construction, for reasons of installation and subsequent mobility. To lessen summer heating, measures must be taken which reduce the solar energy penetrating the room. For this reason the window area can be reduced, or a glass, /63 or a method of mounting glass, can be used which has a lower transparency to radiation, that is, a smaller glass characteristic value of G. Figure 2 shows the maximum air temperature increase as a function of G value, for a small and a large window. It is apparent from this figure that room heating increases linearly with increasing glass characteristic value, for both light and heavy construction. If, for example, an air temperature increase of 10 degrees is still considered permissible in a room with a large southern window occupying 80% of the outer surface of the wall (lower diagram), then this limit can be maintained with heavy construction using a sun protective glass with a characteristic value of G 42. For a room of light construction, a glass with heat protective devices (glass characteristic value G 12) must be chosen. With a small window with a surface occupying 30% of the external wall (upper diagram) other circumstances prevail. Here a room of heavy construction will maintain the permissible limit in any case, regardless what kind of glass is used. For a room of light construction a glass with a characteristic value of G 52 can be chosen, that is, a glass which protects against the sun only slightly better than the normal, clear, double pane glass.

The preceding explanations make clear that the architect has available to him a series of purely constructive means to solve satisfactorily the problem of summer room heating. In the first place a choice of inner construction materials must be coordinated with the glass and shading elements used. The current American method is to combat unbearably high room air temperatures in modern glass structures through the application and operation of expensive climatological installations. This model should only be used if comfortable temperature conditions cannot be achieved by purely constructive means. This may be necessary in some special cases - especially when heat generation internal to the room is added to the sun radiation penetrating the glass surfaces. But as a rule the suitable coordination of building and window construction can create tolerable room climatic conditions without excessive technical expense.